README Document for

Nimbus 5 THIR
Temperature-Humidity Infrared Radiometer
Level-1 Data Products:
THIRN5L1CH67
THIRN5L1CH115

January 17, 2013

Version 1.0

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Revision date	Changes	Author
01/17/2014	Initial version	James Johnson

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1 Introduction

1.1 Brief Background

This document applies to the Nimbus V Temperature-Humidity Infrared Radiometer (THIR) 6.7 micron and 11.5 micron channel Level-1 data products.

The Nimbus V satellite was successfully launched on December 11, 1972. Primary experiments included: (1) a Temperature-Humidity Infrared Radiometer (THIR) for measuring day and night surface and cloud top temperatures, as well as the water vapor content of the upper atmosphere, (2) an Electrically Scanning Microwave Radiometer (ESMR) for mapping the microwave radiation from the earth's surface and atmosphere, (3) an Infrared Temperature Profile Radiometer (ITPR) for obtaining vertical profiles of temperature and moisture, (4) a Nimbus-E Microwave Spectrometer (NEMS) for determining tropospheric temperature profiles, atmospheric water vapor abundances, and cloud liquid water contents, (5) a Selective Chopper Radiometer (SCR) for observing the global temperature structure of the atmosphere, and (6) a Surface Composition Mapping Radiometer (SCMR) for measuring the differences in the thermal emission characteristics of the earth's surface.

The orbit of the satellite can be characterized by the following:

- circular orbit at 1100 km
- inclination of 100 degrees
- period of an orbit is about 107.2 minutes
- orbits cross the equator at 26 degrees of longitude separation
- sun-synchronous

The Nimbus V THIR 6.7 micron data are available from December 19, 1972 (day of year 104) through March 12, 1975 (day of year 071). The 11.5 micron data are available for the same time period. The Principal Investigator was Mr. Andrew W. McCulloch.

1.2 Instrument Background

The THIR is a two channel high resolution scanning radiometer designed to perform two major functions:

- 6.7 micron channel gives information on the moisture content of the upper troposphere and stratosphere and the location of jet streams and frontal systems. The water vapor channel has a resolution of the sub-point is 22 km and operates mostly at night.
- 10.5 – 12.5 micron channel provides both day and night cloud top or surface temperatures. The ground resolution at the sub-point is 8 km and operates day and night.

The optical system of the Nimbus THIR instrument consists of a scan mirror, a telescope, and a dichroic beam splitter and is illustrated in Figure 1. The scan mirror is inclined to 45 degrees to the axis of rotation (scans perpendicular to flight path) and the scan rate operation is 48 revolutions per minute. The field of view scans across the earth from east to west in daytime and west to east at night when traveling northward and southward respectively. A dichroic beam splitter divides the energy into two channels. A 21 milliradian channel detects energy in the 6.7 micron band while a A 7.0 milliradian channel detects energy in the 105-12.5 micron band. In both cases a germanium immersed thermistor bolometer is used.

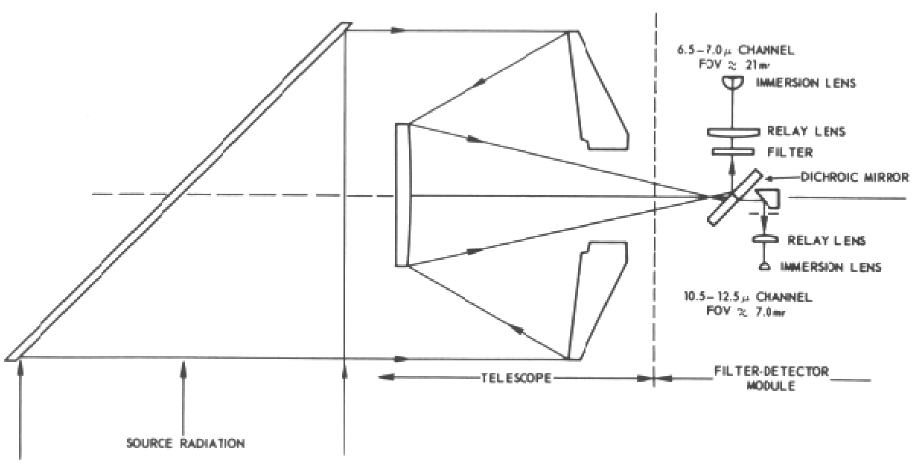

Figure 1: Nimbus THIR Optical Schematic

1.3 Brief background on algorithms

The Nimbus V THIR data was generated from the spacecraft telemetry, attitude data, orbital data, digitized radiation data, and the Nimbus radiometer calibration package. The data were originally created on IBM computers using a 36-bit architecture. Further information can be found in the Nimbus V Users' Guide.

2 Data Organization

2.1 Background

2.2 Granularity

The Nimbus V 6.7 and 11.5 micron THIR data were originally archived on 7- or 9-track tapes. The data were stored in 36-bit IBM binary format. A Canadian company (JBI) was contracted to restore to disks all Nimbus THIR tapes. The content of each tape was written using a proprietary format (TAP) that allowed records to be flagged. Since tapes may contain several files and in some cases several orbits, the content of each file on a tape was retrieved and stored in a separate file using the same TAP format.

The Nimbus THIR tapes were archived at the Washington National Records Center. The tape recovery process involved using specially developed tape drives, bit detection and processing techniques to read the magnetic tapes and store the recovered data in TAP (tape emulation format). Nimbus V THIR data covered about 11 months of observations, and about 98% of the tapes were successfully restored.

Because a tape may contain multiple files, and in some cases multiple orbits, each tape was read and the content of each file stored on a separate file on disk. The overall TAP format and data on tape was preserved. The TAP files are archived and ingested at the Goddard Earth Sciences Data and Information Services Center (GES DISC) and are available for users to download.

2.3 File Naming Convention

The Nimbus V THIR Level-1 data files are named according to the following convention:

Nimbus5-THIR<*channel*>_<*date*>_<*orbit*>_<*tape*>.TAP where:

channel: is either CH67 for the 6.7 micron or CH115 for the 11.5 micron channel

date: is the starting date and time (UTC) of the data in the format *YYYY***m***MMDD***t***hhmmss*:

- *YYYY*: 4 digit calendar year (e.g. 1973)
- *MM*: 2 digit month (e.g. 01 for January)
- *DD*: 2 digit day of the year (e.g. 18 for day five)
- *hh:* 2 digit hour (0-23) (e.g. 19 hours)
- *mm:* 2 digit minute (0-59) (e.g., 49 minutes)
- *ss:* 2 digit seconds (0-59) , (e.g. 13 seconds)

orbit: is the 5 digit orbit number preceded by the letter ‘o’ (e.g. **o**00518)

tape: indicates the original tape identifier (e.g. DR1064)

Note: in case of files with the same start time (for example one file from the primary tape and the second from a backup tape) the file names will be the same up to the tape identifier, which will be different. File sizes may be different.

2.4 File format (TAP)

2.4.1 TAP bytes

Each byte restored from a magnetic tape is stored in a byte as described in the following Figure 2. The 7th bit is flagged to 1 when a byte was not restored correctly; otherwise it is set to 0. The 6th bit is the tape parity bit as stored on tape.

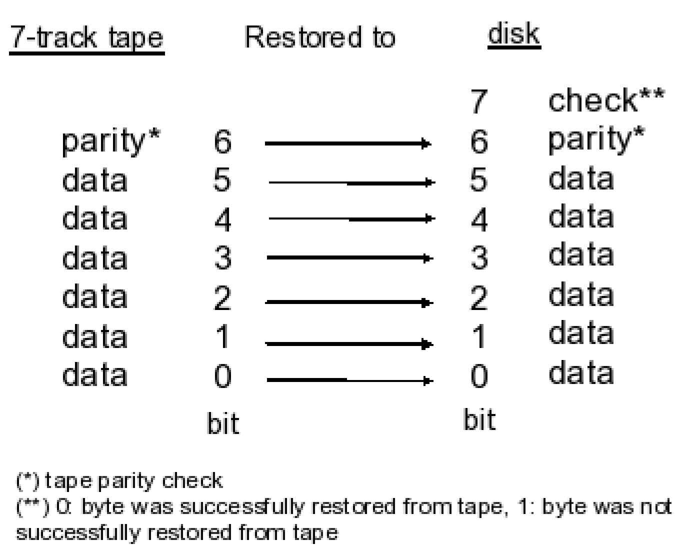

Figure 2: Data restoration process

2.4.2 TAP headers

TAP headers are interleaved between the Nimbus THIR data records to indicate the length of the following and preceding data records. A TAP header is a 4 byte record which follows the following convention.

- A number greater than zero indicates the length of a record
- A negative number indicates that a record has bytes that could not be restored from tapes and filled with zeros. The length of a record is obtained by taking the absolute value.
- a zero indicates the start of a file
- Two consecutive TAP headers with zero values are used to specify the end of a file.
- A data record is preceded by a header and followed by a header listing the length of the data record

An example on how to read a TAP header is illustrated in Appendix 7.1

2.4.3 Nimbus THIR Word

The basic unit of the Nimbus THIR data is a 36-bit IBM binary word. This means that in order to extract a 36-bit word from the restored files, six bytes (8-bits) must be read, the 6^{th} and 7^{th} bit removed from each byte, and the remaining bits of each byte combined.

To preserve space while maintaining a good resolution, a scaling technique was used when the data was originally created and stored on magnetic tapes. The idea was to multiply a number by a factor before storing the value to tape. Nimbus THIR data can be converted back to the initial value by dividing the stored value on tape by 2**(35-B), where B is the scaling factor listed on the Nimbus THIR Data record format tables.

A word of 36 bits with a scaling factor of B is converted by using the relation:

value = (integer value of 36 bits) / (2**(35-B))

When a word is divided in two ½ Word (WordD, and WordA), the actual values are converted by using the relation:

A wordD of 18bits with a scaling factor of B is converted in real by using the relation:

value = (integer value of 18 bits) / (2**(17-B))

A wordA of 18bits with a scaling factor of B is converted in real by using the relation:

value = (integer value of 18 bits) / (2**(35-B))

The scaling factor is mentioned and used in tables describing the Nimbus THIR records.

An example on how to read a 36-bit IBM binary word in C is illustrated in Appendix 7.2

2.5 Data Structure Inside a File

Two TAP 4 byte headers are stored before and after each Nimbus THIR records. The first Nimbus THIR record is an orbit data document record (102 bytes) followed by multiple data records. A Nimbus THIR data record is composed of a Data record documentation followed by several swath data records. The length of a data record (L) in words can be computed using the relation.

L = (swaths per records)*(words per swath) + (number of nadir angles) + 7

The overall structure of the Nimbus THIR files is depicted in Figure 3

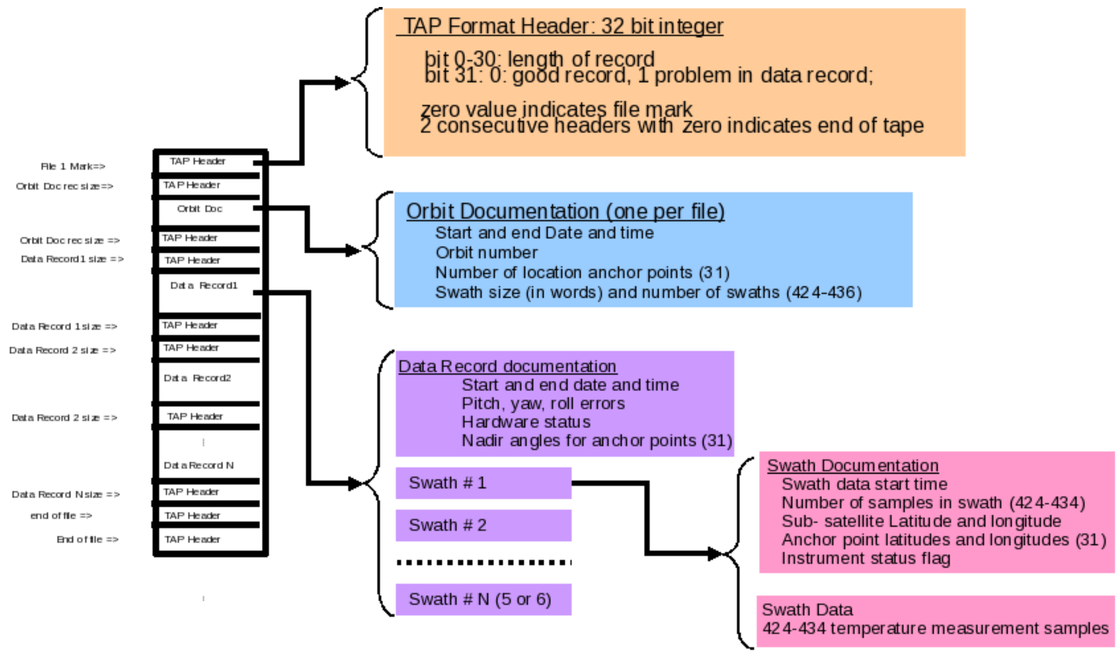

Figure 3: Nimbus THIR data file structure

2.6 Key metadata fields

These are most likely to be used by users:

Temporal

- start Date / Time
- end Date/ Time

Geolocation

- latitude
- longitude

3 Data contents

Described below are all the parameters associated with the Nimbus THIR files.

Table 2 (page 19) describers in details all the parameters associated with an orbit. There is one orbit documentation record per file.

Table 3 (page 20) describes in details all fields in a record documentation. There is one data record documentation per data record

Table 4 (page 21) describes in details all fields in a swath data record. There are multiple swath data records in a single data record.

4 Data services

Nimbus V THIR products can be searched and ordered by using Reverb, ECHO's next generation metadata and services discovery tool at:

http://reverb.echo.nasa.gov/

5 Data interpretation and screening

5.1 Geolocation

The Nimbus pointing accuracy is better than 1 degree in pitch and roll with 1 degree pointing error that corresponds to a sub-satellite geolocation error of 20 km. The THIR radiometer scans the earth in a clockwise direction from right to left. Each earth scan is defined by a family of mirror nadir angles. For each mirror angle, the latitude and longitude of the corresponding point on the earth's surface is recorded. The position of individual samples between two anchor points is determined by interpolation.

The latitude and longitude of the corresponding point on the earth's surface are used as references in computation of positions for each sample. There is still no information available describing exactly how many anchor points were used for geolocating the pixels across a swath.

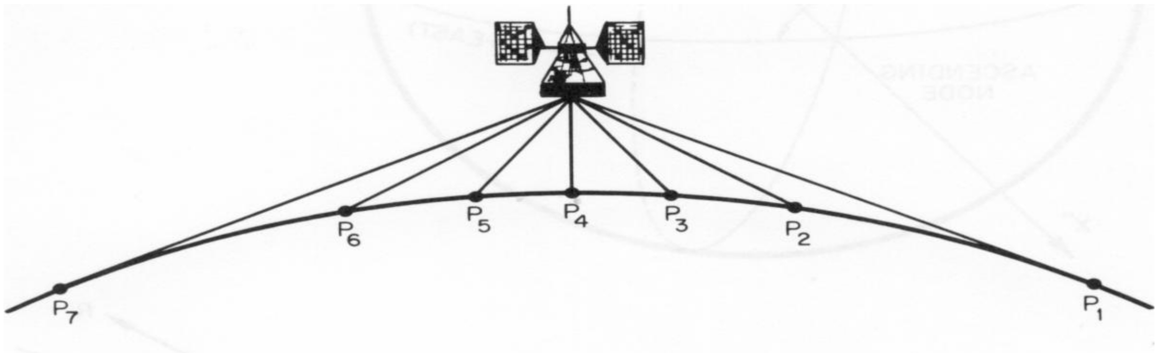

Figure 4: Nimbus THIR anchor points

6 More information

6.1Web resources

NASA/GSFC

Nimbus Documentation:

ftp://acdisc.gsfc.nasa.gov/data/s4pa/Nimbus5_THIR_Level1/THIRN5L1CH67.001/doc/

ftp://acdisc.gsfc.nasa.gov/data/s4pa/Nimbus5_THIR_Level1/THIRN5L1CH115.001/doc/

6.2 Point of contact

URL: http://disc.gsfc.nasa.gov/

Name: GES DISC Help Desk

E-mail: help-disc@listserv.gsfc.nasa.gov

Phone: 301-614-5224

Fax: 301-614-5268

Address: Goddard Earth Sciences Data and Information Services Center

Code 610.2

NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

6.3 References

- Nimbus V Users' Guide, November 1972

7 Appendices

7.1 Example of a C routine to read TAP headers

Following is an example on how to extract the record length from the TAP headers

```
int ReadHeader(ifd)     /* read header */
int ifd;

/* This function reads a TAP header (4 bytes) and return
   the size in bytes of the next record to read
     input
            ifd: file reference
     output
            reclen: size of the next record in bytes
*/

{
unsigned char     bytebuf[200];
int   j, size, value,reclen,signbit;

     size = read( ifd, bytebuf, 4) ;      /* read header */

     value = 0;
     for (j=0 ; j<=3 ; j++ )
         {
             value = value << 8;          /* shift left by 8 bits */
             value = value | bytebuf[j];
         }
     reclen = value;
     return reclen;
}
```

7.2 Example on how to read a 36 bit binary word using C

Below is an example of a C routine to extract the 36 bit word (out of 6 unsigned bytes), remove the most significant bits of each byte and store the content into a long long interger.

```
long long GetWord (initval,len)

unsigned char  initval[];     /* buffer containing the binary data */
int len;                      /* number of bytes */
/*   this function removes the 2 most significant bits of each byte
     and concatenates the "len" bytes (with the 2 bits removed)
     into an integer
     input
          initval array containing the bytes
          len     number of bytes to clean and concatenate
     output
          value   integer containing the bytes cleaned and concatenated
*/
{
int j,pos;
unsigned char  byteclean;
long long value,signbit,res, signval;

   value = 0;
   pos=0;
   signval = 1;
   for (j=0 ; j<len ; j++ )
      {
         if ( j == 0 )
            {
               signbit = initval[pos] & 0x20;   /* get sign bit */
               if ( signbit == 32 )
                  {
                     value = value << 5;  /* shift left by 5 bits
                                             to remove sign bit */
                     signval = -1;
                     byteclean = initval[pos] & 0x1f;
                     value = value | byteclean;
                  }
               else
                  {

                     value = value << 6;  /* shift left by 6 bits
                                             to remove sign bit */
                     byteclean = initval[pos] & 077; /* remove the 2
                                               most significant bits */
                     value = value | byteclean;
                  }
            }
         else
            {
               value = value << 6;        /* shift left by 6 bits */
               byteclean = initval[pos] & 077;   /* remove the 2 most
                                                    significant bits */
               value = value | byteclean;
            }
         pos++;
      }
   value = value*signval;
   return value;

}
```

7.3 Description of all metadata fields

Following is a list of the XML metadata fields and a brief description for the Nimbus THIR data.

Table 1: Nimbus THIR XML metadata description fields

field	Description	value
Shortname	Short product name	THIRN5L1CH67 or THIRN5L1CH115
Longname	Long product name	Nimbus-5/THIR Level 1 Brightness Temperature at 6.7 (or 11.5 microns)
VersionID	Product or collection version number. Does not refer to the algorithm version of the processed data.	Example: 001
GranuleID	Granule ID, i.e. the name of the file	Example: Nimbus5-THIRCH115_1973m0118t194913_o00518_DR1064.TAP
Format	Proprietary File Format (see section on TAP for a full description)	TAP
TotalSize	Total Size of the granules in Bytes	Example: 7763216
Insert Time	Date and time when the granule was archived. The date is YYYY-MM-DD and time is in hh:mm:ss format.	Example: 2013-12-27 21:23:57
RangeBeginning Date	Beginning Date when the data was collected. Format is YYYY-MM-DD.	Example: 1973-01-18
RangeBeginning Time	Time of Beginning Date when the data was collected. Format is hh:mm:ss.	Example: 19:49:13
RangeEnding Date	Ending Date when the data was collected. Format is YYYY-MM-DD.	Example: 1973-01-18
RangeEnding Time	Time of Ending Date when the data was collected. Format is hh:mm:ss.	Example: 21:37:31

field	**Description**	**value**
File Checksum Type	Type of Checksum	CRC32
File Checksum Value	Value of the checksum using cksum	Example: 839582611
File Size in Bytes	Size of the file in Bytes	Example: 7763216
Platform instrument	Name of the instrument	THIR
Platform Sensor	Name of the sensor	THIR
Gpolygon latitude	Latitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case. Each point of a rectangle is identified by its latitude and longitude	Example: -80.000000 -90.000000 -90.000000 -80.000000
Gpolygon longitude	Longitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case.Each point of a rectangle is identified by its latitude and longitude	Example: 180.000000 180.000000 -180.000000 -180.000000
Orbit	Satellite orbit number. There is one orbit per file. A given orbit may have several files (partial orbits or data collected from different stations)	Example: 518
Average Elevation	Average elevation in km of the satellite during an orbit	Example: 1109.309
Station Code	DAF Station identification code	Example: 51
Elapsed_Min_ Time	Duration in minutes of data collected during an orbit	Example: 108

7.4 Description of orbit documentation records

This record is unique for each file and provides information on the starting and end Date/time for a file, size and number of swaths, orbit number, and the number of anchor points used to identify the geo-location of the data.

Table 2 Describes in detail the fields, units, and scaling factors.

Table 2: Nimbus THIR Orbit Documentation record

Word No.	Quantity	Units	Scaling	Remarks
1	Channel ID	Integer	B=35	Equals 67 for 6.7 micron channel or 115 for 11.5 micron channel
2	Date	MMDDYY	B=35	Date of interrogation for this orbit (MMDDYY 2/5/64 is (020504) in octal. Date of interrogation seems to be the processing date.
3	Nimbus Day	----------	B=35	Start day of the year for this file (orbit)
4	Hour	hh	B=35	Start hour for this file/orbit
5	Minute	mm	B=35	Start minute for this file/orbit
6	Second	ss	B=35	Start seconds for this file/orbit
7	Nimbus Day	------------	B=35	End day of the year for this file (orbit)
8	Hour	hh	B=35	End hour for this file/orbit
9	Minute	mm	B=35	End minute for this file/orbit
10	Second	ss	B=35	End seconds for this file/orbit
11	Mirror Rotation	deg/sec	B=26	Rotation rate of radiometer mirror
12	Sampling Frequency	samples/sec	B=35	Digital sampling frequency per second of vehicle time
13	Orbit Number	------------	B=35	Orbit Number
14	Station Code	------------	B=35	Data Acquisition Facility (DAF) Station identification
15	Swath Block size	------------	B=35	Number of 36-bit words per swath
16	Swaths/records	-------------	B=35	Number of swath per record

Word No.	Quantity	Units	Scaling	Remarks
17	Number of locator points	--------------	B=35	Number of anchor points per swath for which latitudes and longitudes are computed

7.5 Description of Data Record Documentation

The data record documentation is described in Table 3

Table 3: Nimbus THIR Data Record Documentation

Word No.	Quantity	Units	Scaling	Remarks
1D	Nimbus Day	-------	B=17	Start Day of the year for this data record
1A	Hour	hh	B=35	Start hour for this data record
2D	Minute	mm	B=17	Start minute for this data record
2A	Second	ss	B=35	Start seconds for this data record
3D	Roll Error	Degrees	B=14	Roll Error at start Date/time (word 1 and 2) for this record
3A	Pitch Error	Degrees	B=32	Pitch Error at start Date/time (word 1 and 2) for this record
4D	Yaw Error	Degrees	B=14	Yaw Error at start Date/time (word 1 and 2) for this record
4A	Height	Km	B=35	Height of the spacecraft at start Date/time (word 1 and 2) for this record
5D	Detector Cell temperature	Degrees K	B=17	Measured temperature of detector cell at start Date/time (word 1 and 2) for this record
5A	Electronics temperature	Degrees K	B=35	Measured temperature of electronics at start Date/time (word 1 and 2) for this record
6D	Reference Temperature A	Degrees K	B=17	Measured Temperature of housing at start Date/time (word 1 and 2) for this record

Word No.	Quantity	Units	Scaling	Remarks
6A	Reference Temperature B	Degrees K	B=35	Measured Temperature of housing at start Date/time (word 1 and 2) for this record
7D	Reference Temperature C	Degrees K	B=17	Measured temperature of housing at start Date/time (word 1 and 2) for this record
7A	Reference Temperature D	Degrees K	B=35	Measured temperature of housing at start Date/time (word 1 and 2) for this record
8	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the first anchor point and measured in the plane of the radiometer
-----				

N	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the last anchor point and measured in the plane of the radiometer

7.6 Description of a Swath Data Record

Table 4: Nimbus THIR Swath Data Record

Word No.	Quantity	Units	Scaling	Remarks
(N+1)D	seconds	ss	B=8	Seconds elapsed since the start of the Date/time of this data record
(N+1)A	Data population	-------	B=35	Number of data points in this swath
(N+2)D	Latitude	Degrees	B=11	Latitude of the subsatellite point for this swath
(N+2)A	Longitude	Degrees	B=29	Longitude of the subsatellite point for this swath, positive westward 0 to 360

Word No.	Quantity	Units	Scaling	Remarks
(N+3)	Flags	------	------	Reserved for flags describing this swath
(N+4)D	Latitude	Degrees	B=11	Latitude of viewed point for the first anchor point
(N+4)A	Longitude	Degrees	B=29	Longitude of viewed point for the first anchor point
-----				

(N+3+M)D	Latitude	Degrees	B=11	Latitude of viewed point for the Mth anchor point
(N+3+M)A	Longitude	Degrees	B=29	Longitude of viewed point for the Mth anchor point
(N+4+M)D	THIR Data	Degrees	B=14	THIR temperature measurement
(N+4+M)A	THIR Data	Degrees	B=32	THIR temperature measurement

(N+K)D	THIR Data	Degrees	B=14	THIR temperature measurement
(N+K)A	THIR Data	Degrees	B=32	THIR temperature measurement

7.7 Detailed tables describing all flag fields

7.7.1 Definition of flags describing each THIR swath

The flags describing the status of each THIR are listed in Table 5

Table 5: Nimbus THIR swath flag definition

Flag	Bit	Definition	Yes	No
1	35	Summary Flag. All checks defined by flags 2 through 12 are satisfactory. (Each flag is zero)	0	1
2	34	Consistency check between sampling rate, vehicle time, and ground time is satisfactory.	0	1

Flag	Bit	Definition	Yes	No
3	33	Vehicle time is satisfactory	0	1
4	32	Vehicle time has been inserted by flywheel	1	0
5	31	Vehicle time carrier is present	0	1
6	30	Vehicle time has skipped	1	0
7	29	unassigned		
8	28	Sync pulse recognition was satisfactory	0	1
9	27	Dropout of data signal was detected	1	0
10	26	unassigned		
11	25	unassigned		
12	24	Swath size satisfactory when compared with the theoretical swath size	0	1
13	23	unassigned		

7.7.2 Definition of flags for individual measurements

The flags describing the status of each individual measurement are illustrated in Table 6

Table 6: Nimbus THIR individual measurement flags

Prefix	TAG	Definition	Yes	No
S	18	The particular measurement is below the earth space threshold	1	0
1	19	unassigned		
2	20	unassigned		

7.8 Quality assurance procedures

7.8.1 Data Producer QA

The Data Producer’s QA information can be found in the XML metadata file under the section ProducersQA. The information begins with the following:

```
Record No, Bytes, Bad bytes
0,filemark
1,84,0
2,filemark
3,102,0
4,11928,0
  :
<n-1>,11928,0
<n>,filemark
```

On each line there are 3 comma separated numbers: the first is the record number, the second is the record length in bytes, and the third is the number of bad bytes. The first Record #0 is a filemark which separates different files. Record # 1 has 84 bytes - this is the BCD header length. If the number of bad bytes is 0, this indicates the header is good. If the number is non-zero, there are bad bytes in the header. Record # 2 marks the end of the BCD header, and the start of the next file record. Record #3 has 102 bytes - this is the data header length. If the number of bad bytes is 0, this means all bytes are good, if the number is non-zero, there are bad bytes in the header. Record #4 is 11928 bytes. This is the nominal data record length. If the number of bad bytes is 0, that indicates this data record is good, if the number is non-zero, there are bad bytes in the data record. From this point, all subsequent records are data records and should have a length of 11928 with no bad bytes. A final filemark will indicate the end of the file. Sometimes the data are split into different orbits or orbit section files, and this will be noted with another filemark

7.8.2 Physical QA

Each restored file was read and its corresponding orbit documentation was extracted and used to derive the file name and to create a XML metadata file.

For each file the number of “bad” bytes, parity errors, “bad” records was derived.

Plots of selected swath were generated (with and without a world map).

7.8.3 Science QA

A script was used to read and plot the data to see if the data look scientifically valid and whether the metadata (start/end times, orbit numbers, geolocation values look reasonable).

7.9 Image Files

None available at this time.

7.10 Acronyms

DAF: Data Acquisition Facility

ECHO: EOS Clearinghouse

EOS: Earth Observing System

GES DISC: Goddard Earth Sciences Data and Information Services Center

GSFC: Goddard Space Flight Center

THIR: Temperature-Humidity Infrared Radiometer

L1: Level-1 Data

NASA: National Aeronautics and Space Administration

Reverb: ECHO's Next Generation Metadata and Service Discovery Tool

QA: Quality Assessment

UT: Universal Time